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"RESEARCH INVESTIGATIONS IN AND DEMONSTRATIONS OF
REMOTE SENSING APPLICATIONS TO URBAN ENVIRONMENTAL PROBLEMS"

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FINAL REPORT

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ABSTRACT

User interest in the application of innovative technology to urban problems has not waned.

Pilot experiments in traffic analysis, neighborhood quality, land use and other areas, have demonstrated the feasibility of remote-sensing technology. These experiments suggest that the information can be acquired rapidly, accurately and economically when compared to conventional methods.

It is suggested that further demonstration projects are needed for development of application.

This is still an important area of endeavor which will be of direct benefit to basic national needs and should be pursued with vigor.

Introduction

This project began with a simple concept and has proceeded through a complex gestation. The previous effort, and this continuation, is based on the premise that:

Since we have made accomplishments in space and on the moon, we should be able to use this new perspective for improving our condition on earth.

The development of new technology and the systematization of multiple technologies as required for the accomplishments in space should provide the mechanisms and incentives for applying these tools to problems in the urban scene.

In cataloging our resources and problems, we discover an abundance of both. There are a variety of sensors and platforms for data gathering and considerable experience in handling large quantities of data. Many urban problems require solutions based upon history, current status and projection. The present methodology is limited in effectiveness by the necessary use of "brute-force" methods which are cumbersome, slow and lack detailed data because of cost and time constraints.

In interrogating prospective users, we find a consistent response of frustration with present methodology and an earnest desire for better tools.

The scope of need becomes apparent as we examine the list of potential users.

User Analysis

Early in the project effort it became apparent that the problem was not to find a potential user, but rather, the problem was to adequately assemble and identify a list of potential users. A preliminary list and analysis of potential users has been prepared by the City Planning Commission, Harold Katner, Executive Director. This report is appended as APPENDIX A. In this report, Mr. Katner

has prepared a list of City and Federal Agencies which have a direct involvement in urban problems for which potential assistance in solution seeking exists within this new technology.

As an involved user, he identifies six major areas of urban planning wherein better solutions are needed.

- a. Population Characteristics
- b. Economic Factors
- c. Land Use and Planning
- d. Traffic and Transportation
- e. Urban Services
- f. Urban Quality

Some of these problem areas in planning can be served directly by remote sensing, others can be served only by indirect applications.

For example, the problems of traffic and transportation are such that solutions will require a large data base over significant time intervals. It is desirable to understand the traffic variables, such as speed, volume and density, for specific major arteries. However, the analysis of arterial flow does not include the relative impact of feeder streets or alternate, non-arterial,

pathways. As the artery achieves significant traffic loading, the loading of secondaries will increase and the major traffic problems may then shift to collateral routes. Remote sensing methodology, such as aerial photography, provides a synoptic perspective which is capable of sufficient data gathering to examine problems of the total circulation. This does not imply that there are no boundaries or limits but rather that the boundaries and limits are much broader than those presently in use. With remote sensing, it would be possible to gather data over areas, such as the central business district or specific urban and suburban areas.

Due to the target size, it appears that future applications in traffic and transportation will be constrained to use large scale systems, such as aerial photography.

In some of the other, urban planning areas, satellite acquired data can demonstrate utility.

Urban Quality and Land Use data can be derived from satellite data. This is within present capabilities because the target size is within resolution capability, the time rate of change is relatively slow and the present sensor complement provides data which can be readily processed by advanced analytical methods. The economics of this application are realistic in that a single satellite can provide such data for a large number of cities and towns.

From this data base, the planners can make reasonable projections and recommend appropriate steps for correcting problems and enhancing beneficial trends. From an understanding of growth or translocation trends, the planner can make projections for future requirements of Urban Services.

A recent example of suburban application was seen in the study of environmental impact of a by-pass interstate highway which was planned to pass through upper estuarine wetlands. It was shown from previous satellite data (LANDSAT -1) that most of the wetland portion of the route passed through areas which were no longer viable wetlands due to other influences.

With regard to Economic Factors it has been shown that the parking lot occupancy could be assessed from satellites. In the case of suburban or other large shopping centers this can be used to estimate retail sales trends.

These are some of the ways in which these methodologies can be of direct assistance to the urban planner.

A subsequent and parallel effort by Drs. Wagner and Thayer characterizes a series of potential uses defined for specific city agencies, APPENDIX B. This is a list and description of specific problems which could be helped toward solution. Many of these needs could be enhanced via simple demonstration projects and thus bring the technology to prompt, specific use.

The first element of this appendix describes the need and interest of the Park and Parkway Department in remote sensing application. A series of low-altitude (10,000 feet) color-infrared photographs were made over several boulevards in New Orleans. Ground truth data was gathered in several areas by local botanists and staff of Park and Parkways. This very limited study revealed that most of the tree types were identifiable by visual inspection of the films. There were several instances where the redness of certain trees appeared to be somewhat "washed-out". Closer examination on site revealed that these trees were under stress and corrective measures were instituted.

The feasibility of evaluating Urban Blight is dealt with later in the report.

The potential uses of the Recreation Department are similar in application as those previously described in Land Use planning.

The use of remote-sensing by Police and Fire Departments is an important application for which little has been done in the way of test or pilot experiments. The need exists and further exploration is desirable.

Most of the anticipated applications of the Dock Board can be satisfied by conventional, controlled aerial photography in the same way that the utility companies use these techniques in their function and planning.

The City of New Orleans and environs face the threat of flooding every year at the time of high water in the Mississippi River. This threat is effectively answered by the existence of extensive levees. The integrity and maintenance of this levee system is among the responsibilities of the Dock Board. It has been suggested that low altitude color-infrared photography of the levees prior to high water stage may be of use in anticipating potential trouble spots. No supporting test experiments have been performed.

These efforts dramatize the need for application and the enormity of the problem of broad application. There is no question of the need for application, only the question of how to provide the application and assist the user.

Because of the enormity of the problem and limited resources, two primary problem areas were addressed, Transportation and Urban Quality.

Transportation and Traffic

The use of sensors on remote platforms allows the acquisition of information of a segment of the urban scene with relative ease. Whether by photography or other sensing system, this is a synoptic view at one point in time. At this point, all traffic is "frozen" at some geographical coordinates. At some later point in time, all moving vehicles will be at different coordinates and their displacement will be directly related to their velocity. This suggests the use of time-lapse photography or time-lapse data extraction.

Preliminary experiments have been performed to demonstrate the feasibility of time-lapse aerial photography to study traffic problems. The results of these experiments are described APPENDIX C. These experiments were successful in demonstrating the acquisition of necessary, meaningful data and defining some of the parameters for effective application. The experiments were not extensive enough to provide sufficient data to the traffic engineers to address a specific traffic problem. As a successful pilot study, it was also demonstrated that more automated systems for data extraction would be most desirable.

There are two further experiments which should be performed to pursue this application.

The first of these is the examination of high resolution television camera as a primary sensor. In this proposal, the sequential images would be recorded on video tape and the taped images would be processed through an analogue to digital converter and introduced as computer input. The computer can be programmed to do gross image registration and frame-to-frame subtraction. The resultant difference will be the paired positive and negative "images" of anything that moved between frames. This offers the prospect of a much simpler data extraction scheme than the use of flying spot scanners for photographic analysis.

The second experiment which should be performed is a limited test of the time-lapse system on a specific area to address a specific need for a traffic engineer. It is presumed that the conventional data gathering would take place to allow comparison of results. This can be a limited scope study such as a corridor analysis but must be of current significance to demonstrate system value on a data and relative cost basis.

Urban Quality

The expected changes in urban quality occur relatively slowly and the time-lapse base is significantly different from that of traffic. It may be sufficient to reassess the data base semi-annually, annually, or even biannually. The requirement exists for a large quantity of data to be extracted relatively infrequently.

In a parallel study on an unfunded contract for a Landsat-1 (ERTS-A) project with NASA, data was acquired from the ERTS sensors in the vicinity of New Orleans. The prime thrust of this effort was to look for environmental impacts on Lake Pontchartrain, north of the City. The study was successful in being able to identify vegetative indicators in the wetlands.

The most significant finding of this study came from a side effort of examining the imagery of the City of New Orleans. A copy of an internal report on this subject is provided as APPENDIX D.

The appended report describes the experimental progression from visual inspection of color photography to more sophisticated discriminant signature analysis for "neighborhood quality".

The ground truth for this study was a combination of the 1960 census and a Neighborhood Quality Study performed in New Orleans in the early 1960's. Most of the data was acquired from a "windshield and clipboard" study at a cost of over \$300,000.

The satellite data study was able to distinguish all four quartiles of degree of "blight" with excellent precision, considering the 10-year time span between ground truth and measurement. In addition the satellite data was able to identify open space and heavy industrial areas.

The study did not include suburban areas for there was no ground truth data for signature verification.

With some additional verification, this application appears to be near usefulness.

The following experiments are suggested for verification of this technique.

Select three urban and/or suburban areas where recent urban blight studies have been done and for which Landsat (ERTS) data exists. The urban areas should be selected on the basis of different ambient vegetative types and the ERTS data should exist for at least two different seasons. Perform the data analysis and compare with ground truth. Evaluate degree of variance. If this succeeds as well as it did in New Orleans, this application from ERTS technology should be put to use.

Program Plan

Due to a number of changes in funding bases since the inception of the project, the establishment of a concise program plan is much more difficult. With regard to Federal Agency support, there has been an apparent, significant erosion in the availability of categorical grants of all kinds to the cities. On the other hand, the cities have received revenue sharing funds which they were not receiving before. However, the increased needs of the cities for funding basic services such as police and fire, essentially preclude any meaningful support for new projects regardless of estimated value.

This suggests that there is no meaningful support base for a basic program plan.

A program plan for the Greater New Orleans Systematic Transportation Analysis Research (STAR) project has been prepared using New Orleans as the demonstration site. This plan encompasses a three-year period and would require several millions of dollars.

In view of the funding problems alluded to in the beginning of this section, it is the author's opinion that this program plan may not be possible at this time and, therefore, an alternate plan is proposed.

The further development of remotely - sensed systems applications to urban problems requires that the system move further from the concept phase and closer to the specific application phase. For example, it is not sufficient to demonstrate that traffic parameters can be measured easier and more accurately by these new methods. It is necessary to demonstrate the

applicability of the method to identifiable traffic problems, such as Corridor Analysis.

It is recommended, therefore, that future development activity be directed toward specific application demonstrations as dictated by funding availability. Some of these targets-of-opportunity will be suggested in the next section.

Suggested Future Effort:

In order to maintain progress in this important effort, it is suggested that several small experimental efforts be pursued. These efforts have been alluded to in previous sections.

Traffic and Transportation

1. Perform a corridor analysis, using this new technology. For demonstration, select a site where such an analysis is being performed by conventional methods and perform the study in parallel. This should demonstrate the increased precision and lower cost of this application.

2. Examine further the methodology for automated data extraction. Most of the effort thus far has been optical and electro-optical methods which extend existing technology. Examples of these devices are large flying-spot scanners and optical systems using degraded spatial filters. It is suggested that the application of television methods be examined as an intermediate and expedient technique. This should require little or no extension of present technology. It is suggested that a high resolution television

system be employed in an "aerial photographic" mode to examine a traffic scene. By reversal of alternate frames in a computer and subtraction of frame pairs, traffic parameters should be easily extractable.

This technique should reduce costs and improve the delay time between data gathering and information availability.

Neighborhood Quality

The application of satellite data to neighborhood quality has been demonstrated but, unfortunately, the timeliness of ground truth may be questionable. There is a significant body of data from LANDSAT for a number of American cities which could be used for further demonstration. For this effort, identify one or more cities which have conducted a neighborhood analysis during the time frame (within 3-5 years) of the LANDSAT data and perform the analysis by means of the satellite data.

Other studies

Using LANDSAT data, similar studies could be easily performed in Land Use and Recreational Siting for urban and suburban areas which have recently performed such studies by conventional methods.

Conclusion:

The basic thrust of using NASA generated new technology is still desirable and germane to the potential solution of some of the problems of urban America.

The prospect of establishing a multi-agency effort in pursuit of these goals is still the method of choice but the attainment of this prospect seems to be remote at this time without further meaningful demonstrations.

The future plan for this effort should focus on specific demonstrations with the goal of generating further interest by the other agencies which could benefit by adoption of new methods.

The ideal objective of many agencies joining forces in the exploration of innovative methodology for the purpose improved problem solving is still the best approach to develop meaningful utility for the methods. It is hoped that further demonstrations could engender increased interest by individual agencies and still lead to the goal of a combined effort.

APPENDIX A

STAR PROJECT

Preliminary User Analysis

Harold Katner
Executive Director
City Planning Commission
City of New Orleans

13-a

FOREWORD

In April, 1970 NASA invited representatives of the City of New Orleans inclusive of a staff member from the City Planning Commission for a tour of their Houston Operations. Following the tour a "brain storm" session was held to discuss the possible application of the knowledge gained from the tour to the special area of interest of the city representatives. During the brain storming session, discussions ensued relative to the possible application of NASA's systems analysis, managerial and implementation skills and photo technology toward the solution of some problems concerning urban planners.

Upon returning to the City of New Orleans meetings were held with representatives of the staffs of the Regional Planning Commission, City Planning Commission, and NASA. Upon request, NASA furnished selected aerial photography to the staffs of the planning agencies with extensive magnifications. Subsequent brain storm sessions and examinations of the photography revealed a tremendous amount of information that might be available concerning transportation, housing and environmental conditions; three major problems confronting Urban America.

This enthusiasm led to the realization that practitioners (planners) had stumbled onto a highly sophisticated technology that might be of major

benefit in obtaining an understanding of urban evolution and the ability to give guidance thereto. A missing element appears to be a theoretical framework in which to attempt to advance this applications concept. Universities were contacted relative to their interest. Extensive fiscal and staff restraints limited their participation but all local universities have expressed strong interest and enthusiasm to participate. Thus emerges a triumvirate of practitioners, technologists, and theoreticians.

Following a series of additional "brain storming" sessions a concept emerged in which aerial photography and computer technology should be wed in a manner that would produce viable and useful information to assist in the understanding and planning of Urban America as well as to guide the elected and appointed officials in their daily decision making process.

The university interests began to emerge as a coordinating role. Upon request, NASA offered assistance to follow-up on the extant status of the technology to determinate what was available as well as what might be needed. The planners in turn attempted to define the range of users of this equipment and to what extent the development of the concept could be utilized.

A series of meetings were then held with presentations to "users" in the areas of transportation, housing and environment; all phases of govern-

ment, be it local, state or national, have assumed some responsibility.

The response varied from one of awe to that of severe skepticism of the possibility of developing such a concept. However, most of the professionals contacted saw considerable merit to the possibility and urged it be pursued.

As the possible application of such a concept was being further developed NASA agreed to examine the feasibility of using laser beams to "read" aerial photography with direct impulse into the computer banks for storage retrieval and analysis.

Simultaneously, a series of information presentations were made to selected citizens' groups as well as elected officials.

Finally a decision was made that the potentials of this concept was so extensive that an effort should be made to reduce it to writing and an attempt to define a preliminary feasibility study. The following papers represent a brief summary of this two year effort. At this time those who have reviewed the presentation felt it had sufficient merit that it warranted public sponsorship and the attention of our national leaders.

**CITY PLANNING COMMISSION PRELIMINARY STUDY
OF POTENTIAL USERS FOR
GREATER NEW ORLEANS S T A R PROJECT**

A problem associated with the GNO-S T A R Project has been defining the User of any information that may be obtained from the project. This definition is further complicated by the fact that it has a two directional flow. The one direction is obtaining the base data in a manner which the user is accustomed and therefore can utilize it within terms of his existing skills and proficiency. The other direction is an expose' of the system to the user and his application of imagination and thought in giving a directional thrust to the project itself and the possible expression of his base data in terms other than those to which he is accustomed. Example: An index an economist frequently uses in his evaluation of economic conditions within a community is the number of construction and demolition permits issued. As an indication of economic activity, perhaps a similar index could be obtained through aerial photography wherein a comparison of aeriels can demonstrate demolitions. New construction might be measured by the development of an index of construction based on such factors as the growth rate normally accompanying vegetation associated with new development as well as the modification in color of building materials which occur as structures age.

This is merely to point out that the definition of the user's role in the project must be conceived of as dynamic. Attempting to develop techniques which can be applied to the GNO-S T A R Project in the gathering of information in a form currently sought by the user and simultaneously modifying the GNO-S T A R Project to provide him with new or modified indices which may not have been available to him in the past are major goals of the program.

Definition of the User

One approach to the definition of a user might be gained through a cursory examination of an abbreviated planning procedure. Basic to any planning program is the need for extensive information. Such information for purposes of analysis are frequently categorized into a series of areas, commonly referred to as Base Studies. These generally consist of the following:

- a. Population Characteristics
- b. Economic Factors

- c. Land Use and Planning
- d. Traffic and Transportation
- e. Urban Services
- f. Urban Quality

Problems of the Planning Program

The major problem confronting any comprehensive planning program is its ability to have access to this basic information on a historical as well as a current basis and reasonable future projections. A frequent shortcoming of the planning process is the necessity (due to limited techniques available) to spend a considerable amount of time in updating one base study area to the detriment of all others. An illustration of this is the population base data which normally is only available on a ten (10) year basis via the U. S. Census. This is further compounded by an assumption that each decennial period is a typical index of trends and does not represent in any way an atypical year.

Frequently, two or three years may be consumed in securing basic systems data, revising population studies, and defining or redefining goals and objectives to meet current as well as future population needs. During this period of emphasis on population, other areas of base data requirements are totally neglected.

Another major problem in the planning process is the extreme difficulty in correlating the massive amount of information that is needed in each base study area. The individual basic study areas enumerated above do not in reality exist as a separate entity but are closely related to all other base study areas. Not only do the planners have extreme difficulty in the implementation and understanding of the data in any particular base study area, the problems are even further complicated by an efforts to interrelate between basic study areas.

In the absence of being able to maintain current information and reasonable future projections and interrelate basic areas of information, the decision-making process for planners, elected officials, and the public is frequently stymied, and often objectivity is diminished. The decisions then being based on "fad" trends, "expediency," or "emotionalism" rather than rational objectivity.

Another future problem is the inability to store, retrieve, manipulate, and relate these basic studies which also indicates a major deficiency in the area of understanding or how an urban area grows, changes, develops, or re-develops.

It is somewhat like requesting a physician to make a diagnosis of a major illness by telephone. He is precluded from being able to examine in detail the patient which he is attempting to treat. Similarly, planners, people, and elected officials are frequently being asked to render decisions about a community when they do not possess the knowledge and understanding of the community concerning which the decision is being rendered.

In terms of basic study elements necessary in a comprehensive program, the following is a brief description of the type of data needed in the planning process as well as examples of the user's involvement.

POPULATION CHARACTERISTICS

An analysis of population by age, sex, race, income, employment, spatial distribution on a 24-hour basis and social indices, characteristics such as health, welfare, education, and legally defined offenses.

THEORETICIANS

Sociologists, Political Scientists, Economists, Transportationists.

*PRACTITIONERS

Planners, Health Agencies, Criminal Justice System inclusive of Judges, Police, Rehabilitation Offices, and practicing Penologists.

Elected officials for re-districting, educators, specialists in service for the elderly, recreationalists, etc.

*Practitioners have generally been viewed from a Governmental viewpoint which could be further classified by level of abstraction and application into neighborhood, local, State and Federal levels.

ECONOMIC FACTORS

An examination of the "basic" and "nonbasic" elements of the economy along with their relationship to each other and changes that occur over time which are vital to the functioning of the City. Occupation classifications and distribution, unemployment rates, income earned, relative buying power, energy

THEORETICIANS

Economists, Political Scientists, Sociologists, Transportationists.

PRACTITIONERS

Planners, Chambers of Commerce, Real Estate Developers, Bankers, Brokers, potential developers of business concerns, Zoning Boards, elected officials, Assessors.

consumption, banking indices, spatial employment and distribution, changes in technology, wage and price scales, policies and rates of taxation are all important factors.

LAND USE AND PLANNING

Studies designed to provide basic data on land characteristics and various activities that occupy land in the planning area. This data is used to analyze current patterns and serve as a framework for formulating long-range land use plans. Studies relating to land use include: a) mapping physiographic features; b) surveying of existing land use; c) vacant land surveys; d) hydrological and flood potential studies; e) structural and environmental quality surveys; f) land value studies; g) studies of aesthetic features; h) studies of public attitudes and preferences regarding land use, housing conditions, intensity of land utilization.

TRAFFIC AND TRANSPORTATION

An analysis of the need of transportation improvements which are developed into programs, tested for both present and future needs and then scheduled for future construction. All modes of transportation are considered: Air, Water, Roadway, Rail, Transit, and Parking. Also, acknowledged

THEORETICIANS

Economists, Transportationists, Political Scientists.

PRACTITIONERS

Planners, Real Estate Developers, Assessors, Zoning Boards, Architects, Landscape Architects, Urban Designers, Traffic Engineers, Recreationists, Firemen, Sanitation, Police, City Management Specialists, and Urban Renewalists.

THEORETICIANS

Transportationists, Economists, Ecologists, Sociologists.

PRACTITIONERS

Planners, Traffic Engineers, Real Estate Developers, Design Engineers, Bridge Engineers, railroad

is an explicit recognition of the movement of both people and goods.

URBAN SERVICES

The study of the use and future needs for public health, gas, electricity, telephone, water, sewerage, drainage, and refuse disposal services. Studies relate consumption of these services for persons in the City and predict future consumption demand related to population trends and projections.

URBAN QUALITY

The analysis of meteorological conditions and their effect upon the development of land in the City. Climatological and topographical conditions of the environment inclusive of flora and fauna.

engineers, Transit specialists, port authorities, architects, aeronautical scientists, specialists in pollution, airport designers, landscape architects, construction engineers, transit operators.

THEORETICIANS

Economists, Ecologists, Research agencies such as Broad Band cable communication systems specialists.

PRACTITIONERS

Utility engineers, communication specialists, utility companies, sewerage, water, and drainage engineers and companies, health agencies, waste disposal specialists (in collection, reduction, disposition).

THEORETICIANS

Sociologists, Ecologists, Material Research, Environmentalists, Meteorologists, Botanists, Biologists.

PRACTITIONERS

Utility companies, Planners, Public Health, Park Agencies, Street Departments, Utility Engineers, Construction Engineers, Soil Analysts, Landscape Architects, Pollution Experts, Sanitarians.

The above are but a few indications of the potential uses and are intended as illustrations and not a comprehensive listing. A further point also requires some comment. These classifications are not mutually exclusive since a great interdependency exists.

ILLUSTRATION: Although employment and distribution were listed under economy, the need for this data is multifaceted. This is base data required by the transportation expert in preparing origin-destination studies and developing a balanced transportation system. It is information needed by the Zoning Agency in allocation of land uses and preparation of a zoning ordinance. It is needed by the utility engineer in designing the utilities necessary to support the employment industries.

PRELIMINARY CITY PLANNING COMMISSION STUDY
OF FEDERAL AGENCIES THAT MIGHT PARTICIPATE IN
OR UTILIZE DATA FROM THE GNO-STAR PROJECT

POPULATION CHARACTERISTICS

Department of Commerce
Department of Defense
Department of Health, Education and Welfare
Department of the Interior
Department of Justice
Department of Labor
Department of Transportation
Civil Service Commission
Commission on Civil Rights
Equal Employment Opportunity Commission
Interstate Commerce Commission
Office of Economic Opportunity
Veterans Administration

ECONOMIC FACTORS

Department of Agriculture
Department of Commerce
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of Labor
Department of Transportation
Federal Power Commission
Federal Trade Commission
Interstate Commerce Commission
Securities and Exchange Commission
Small Business Administration

LAND USE AND PLANNING

Department of Agriculture
Department of Commerce
Department of Defense
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Labor

URBAN QUALITY (CONT'D)

Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Transportation
Atomic Energy Commission
Environmental Protection Agency
Federal Power Commission
National Aeronautics and Space Administration

LAND USE AND PLANNING (CONT'D)

Department of Transportation
Environmental Protection Agency
Federal Maritime Administration
National Aeronautics and Space Administration
Office of Emergency Preparedness

TRAFFIC AND TRANSPORTATION

Department of Agriculture
Department of Commerce
Department of Defense
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of the Interior
Department of Labor
Department of Transportation
Environmental Protection Agency
Federal Maritime Administration
Federal Trade Commission
Interstate Commerce Commission
National Aeronautics and Space Administration
Office of Economic Opportunity
Office of Emergency Preparedness

URBAN SERVICES

Department of Commerce
Department of Defense
Department of Health, Education and Welfare
Department of Housing and Urban Development
Department of Transportation
Environmental Protection Agency
Federal Power Commission
Federal Trade Commission
Interstate Commerce Commission
Office of Emergency Preparedness

URBAN QUALITY

Department of Agriculture
Department of Commerce
Department of Defense

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INTRODUCTION

Aerial photography can be of great value in urban planning and development.

Many agencies, such as the Soil Conservation Service of the U.S. Department of Agriculture have used aerial photography for many years to compile an accurate and usable record of their designated areas. Other agencies, such as the Corps of Engineers have done likewise.

The record shows much heavier use of aerial photography by agencies having more of a single function responsibility; e.g., agricultural production/analysis. General purpose agencies, such as city planning commissions have been much slower to adopt aerial photography on a large scale. Reasons advanced for this posture generally include considerations of cost, lack of skilled persons to interpret photos, and a belief that information can be obtained in other ways.

City departments, except in the largest metropolitan areas, have also not made wide use of aerial photography. In part, this situation is predictable: unless the city as a whole adopts aerial photography as an integral part of the data effort, the cost to one agency of securing high quality and timely aerial photographs is generally prohibitive. Numerous departments also regard aerial photography as a public relations device useful for strategically placed wall hangings which never fail to draw respectful comments from visitors to the office.

There are very real considerations of cost, type of usage, and necessity of usage which must be honestly and objectively faced before a decision is made to move forward to broader use of aerial photography. In that sense, the decision of whether or not to computerize various functions bears a close resemblance. In fact,

few realize that aerial photos using new technologies can be directly fed into computers and very informative displays will result. Under some conditions, this type of information input and retrieval system may well produce usable planning information at far less cost than a more common method of data gathering and display. Among other things, the graphic is mechanically produced suitable for direct inclusion in reports or briefings.

In New Orleans, the use of aerial photography is sporadic and largely ineffective. Some agencies, although not city agencies, rely very heavily on aerial photos; the Dock Board is a prime user. Other agencies, however, are faced with the limitations previously cited. On reflection, it is not surprising to find that a city caught in a worsening financial situation would be reluctant to embrace a new information process unless they were convinced that great benefit would thereby attend this decision.

The nature of city governments virtually precludes using estimates of cost savings as a realistic benefit. Even if aerial photography could lead to elimination of some jobs now supporting by-hand data collection and analyses, it is hardly likely that these jobs would be deleted in any but the most unusual of circumstances. Thus, it is our thesis that it is not terribly realistic to speak in terms of dramatic cost savings as a result of use of aerial photography. Savings on future costs may be realized but the projection of future information costs is traditionally risky depending as it does on actions in a complex and changing environment.

A different situation exists when the question of a system's ability to meet rapidly rising demands is at issue. Aerial photography has only recently been used in its most advanced applications by the military. The Earth Resources Technology Satellite (ERTS) and Weather Satellites such as those that examine hurricanes are now well publicized civilian applications. Building on those examples -- and the photos available from them -- it is now much more likely we can show the ability of an aerial photo system to increase dramatically the scope and nature of planning information at reasonable cost.

What is lacking now -- and it is to this end this report addresses itself -- is a pragmatic listing of operational uses at the local level. This report is a result of a survey of numerous local officials to ascertain their feelings as to where and how aerial photos could be of aid. In addition, we have inserted other uses which we estimate to be practical even if they have not yet been tried in the city. For clarity, we have broken the report down into individual topic headings on a department or function basis.

POTENTIAL USES OF AERIAL PHOTOGRAPHY FOR THE PARK AND PARKWAYS DEPARTMENT

Ms. Mildred Fossier, Director, the Parks and Parkway Commission, was interviewed regarding the potential uses of aerial photography for planning and managing the parks and parkways of the City of New Orleans. At the outset of the interview, it was learned that Ms. Fossier had in her possession numerous unmounted color infrared (C.I.) photographs of the New Orleans area. At her request she

obtained these C.I. prints from the early STAR project, as she had previously read in a journal that the Swedes had been using these types of photographs for detecting diseased trees. Although there were some attempts to try and make use of the random assortment of pictures, for the most part, they were of minimal help. This was caused by a variety of factors: the lack of stereoscopes for detailed interpretation and analysis; the absence of a photo-mosaic of the entire city of New Orleans; photographs that were useless because of the amount of cloud cover; and the lack of trained personnel for photo analysis and interpretation. Because of a sincere interest and belief that aerial photography, particularly color infrared pictures, can improve both planning and the management aspects of the Park and Parkway Department significantly, she urges further city participation in aerial photography. The following is a discussion of the potential uses of aerial photography (C.I.) for the Park and Parkways Department.

Documentation and Ten Year Plan

The need to record what types of trees and vegetation are in existence and where they are located in the city is a necessary and vital first step for the department. Conducting a comprehensive inventory of the flora would provide a basis from which to prepare a ten year master plan. Without first knowing what plants exist, the preparation of a city wide planting program would be incomplete. Therefore, it is believed that a color infrared film mosaic of the entire city is required before a plan can be developed. The detail of these photographs must be such that the color and types of leaves of trees and plants can be easily recognized. The resulting flora

inventory would produce other important uses such as, plant disease detection, and destruction, maintenance schedules, litter detection, and the impact of new land uses (roads, utility lines) on flora, either on or near parks and/or neutral grounds.

The following will present a discussion of each of these topics.

Plant Disease Detection

Detecting diseases of plants as early as possible is important if they are to survive. Because all the flora that is planted in our public parks and neutral grounds is owned by the city, a financial investment of hundreds of thousands of dollars is represented and needs to be protected. Color infrared photographs can detect tree/plant diseases and thereby save not only the flora but tax dollars as well.

Also, by noting where a diseased tree is one can determine if it is located on "public" or "private" land. If the tree is located on private land, the owner should be notified of the problem so that remedial action can be taken to prevent the disease from spreading to other public and private trees and to avoid possible litigation. A case in point is that a federal jury in Washington, D.C. recently ruled that the D.C. Government is responsible for the upkeep of trees that are not on city property but that overhang city streets. The panel ordered the city to pay \$250,000 to a man who was seriously injured when a 90 foot section of a Tulip Poplar tree fell on his car.

By having healthy and beautiful flora, Ms. Fossier reiterated, that many people continue to stay in the city and not move to the suburbs. Also, she said, the pollution caused by cars, factories, etc., is recycled and cleaned by our

"natural system" of flora. Without our trees, the city would continue to lose people to the suburbs, and its fight against air pollution. By keeping the flora strong and healthy, the city is a better place to live.

Plant Destruction Detection

Over the past years numerous plants and trees have been either destroyed or stolen by people. Destruction of trees can represent a significant financial hardship on the city, especially when a mature tree, such as an oak, sycamore or palm is involved. The American Shade Tree Association has tables that indicate the "present value" of a tree and can be contacted to ascertain the value of a given species of tree.

In the case where a person has been seen destroying a tree, litigation can be instituted in order to obtain money to replace the tree, according to its "present value." To convict a person of this misdemeanor, it is essential to have on hand, proof that a tree did exist. This is where the inventory films can serve as the source of documentation and proof of the existence of the tree in question. During the past year, this situation actually occurred and the party who was charged with the violation was found guilty and forced to pay for the replacement of the tree.

This case probably would not have been won as easily without the aid of a color infrared photograph that was, by chance, taken during the STAR project. Fortunately, the photograph was in the possession of the Park and Parkway Department.

If the city is to protect its natural resources from destruction, it is imperative that a complete inventory be made and available for purposes of replacing trees and plants that have been stolen or destroyed and for supporting legal suits against violators.

Maintenance Schedules

Maintaining the flora by mowing, cultivating, weeding, fertilizing, watering, and litter removal is an ongoing program in the city. Because of limited finances, automated machines have been brought on line to try and keep operation costs down but at the same time keep the parks and neutral grounds as appealing aesthetically as possible. In order to continue to keep pace with rising costs for labor and machinery, improved maintenance schedules will be needed. Ms. Fossier believes that aerial photography can be used as an aid for setting up maintenance schedules and can help save the city money.

Litter Detection

Litter (cans, paper, etc.) in parks and on the neutral grounds represents a potential health hazard (broken glass, cans) and an aesthetically displeasing environment. Left to accumulate, people become concerned and often complain to city officials. The responsibility to maintain the parks and neutral grounds is under the jurisdiction of Parks and Parkways Department. Because litter is a problem in the city, funds must be appropriated annually for its removal. Aerial photographs can be an important tool for locating "specific" litter problems for referral to other city agencies such as the police department or code enforcement section. Once contacted, one of the aforementioned agencies could conduct an onsite visit of the area and or business to determine what is creating the problem and to strongly recommend corrective measures first, with the suggestion of possible litigation. This should improve the control of litter but not the problem.

Impact of New Land Use

Urban areas are continually expanding and land uses therefore change. New roads, utility lines, sewer and water lines, gas lines, are constructed. The park and parkway commission has to determine where roads, and property and pipe lines are "actually" located for the preparation of planting schemes. C.I. films can show, through the differences in the color of vegetation, where these facilities are often located. Once these new facilities are located landscape plans can be designed and implemented.

Summary

Aerial photography, particularly color infrared photography, can be a useful tool for planning and managing the parks and parkways of the City of New Orleans. Major potential uses were outlined with supporting discussion. There is no doubt that aerial photography can benefit the Parks and Parkways Department and the people of New Orleans.

URBAN BLIGHT: THE USE OF AERIAL PHOTOGRAPHY AS AN ANALYTICAL TOOL

The following is a discussion of the potential uses of aerial photographs for urban blight analysis. Five main sections are presented that represent important parts of urban blight analysis. These are: housing, circulation patterns, recreational facilities, utilities, and public meeting places.

Housing

Aerial photography can be used to determine blight in urban areas. Blighted areas are characterized by a large proportion of sub-standard and vacant dwellings, mixed residential, commercial, commercial and/or industrial use, relatively low rent levels, high densities and minority populations. Using roof condition as a proxy for the structure's condition, blight areas can be tentatively determined on a micro-basis.

Once a blighted area has been determined, the density of housing in the area can be ascertained. The size and type of dwellings can be cataloged and "rooftop" analysis can provide strong evidence as to the condition of the dwelling underneath the roof. The assumption here is that if the roof has many missing tiles, has holes in it, or leans heavily to one side, neglect is also likely on the exterior and interior of the dwelling. Since the roof is the most important part of a house and because it provides direct shelter from rainstorms and the summer heat, it is by far the most important indicator of housing conditions.

Another use of aerial photographs can be to show where illegal buildings have been built. These structures are usually built in backyards or in other concealed locations and usually are not on the city tax rolls or up to building code standards. These buildings can represent potential "fire traps" or at least "nasty surprises," and therefore need to be identified and corrective measures taken.

Color infrared photography (C.I.) can be used specifically to determine the relative levels of affluence of those persons residing in an area as a function of the amount of vegetation covering the area.

The location, type, and amount of rubbish and trash (litter) can be determined also by using black and white or color infrared photography. This will aid in fire prevention and control as well.

Circulation Patterns

Color infrared photography can be used to differentiate between the different types of street surfaces and asphalt. Either type of film (C.I. or black and white) can show the condition (cracks, holes, etc.) of roadways, alleys, and walks. Wash-out of road beds can be identified before dangerous conditions occur. The width of roadways and their relation to traffic congestion can be ascertained by using photographs of the area during peak hour traffic conditions.

Color infrared photography also can show the condition of vegetation on the neutral grounds. This application will be discussed in more detail in the section on parks.

The location of junked and or abandoned automobiles (a safety hazard as well as a source of road congestion) can be pinpointed using a good aerial photograph. Congestion points of parking can also be delineated and corrective action taken.

Recreation Facilities

An aerial mosaic of a blighted area can be used to locate open space and determine how these spaces are currently being used (junkyards, vacant lots, playgrounds, etc.). Also, the mosaic can pinpoint various types of indoor recreation facilities such as gyms, theatres, recreation centers, etc.

Utilities (Electrical and Drainage)

The aerial photograph can enable the planner to accurately determine the location of overhead utility poles, their attending lines, and their current condition.

The efficiency of the drainage system can also be surveyed aerially, and by locating where standing water tends to accumulate, the Sewerage and Water Board can determine whether the standing water is caused from land subsidence, unevenness of the ground surface, or if it is a result of a faulty or blocked drain. Standing water, especially in the warmer months, can pose a serious health hazard by acting as a breeding place for mosquitoes and other potential disease carrying organisms.

Public Meeting Places

Aerial photography can show types of churches, their numbers, and their location. It may be possible to locate lodges, such as K.C., Free-mason Halls, etc. This information may help the planner make inferences about some of the social patterns in the blighted area.

Summary

In summary, blight analysis can be effectively conducted through the use of aerial photography, in respect to the topics previously outlined. Time and money can both be saved through aerial photography interpretation. In conclusion, it would appear that aerial photography can be used as a potent tool for urban blight analysis and planning. The applications here would be most apparent for the Community Improvement Agency in its urban renewal and rehabilitation operations, the various Housing Development Corporations, the Department of Building Safety and Permits, the Fire Department, the Department of Health, and the Policy Planning Office of the Mayor.

SOME POTENTIAL USES OF AERIAL PHOTOGRAPHY FOR THE NEW ORLEANS RECREATION DEPARTMENT

The City of New Orleans Recreation Department, NORD, has been contacted on two separate occasions to discuss the uses of black and white and color infrared aerial photography for urban open space and recreation planning. The primary uses of aerial photography were determined to be in two major areas, comprehensive recreation planning and site planning.

Comprehensive Planning

Aerial photography may be applied as a background reference for urban recreation analysis and for determining a variety of uses in open space. Color infrared photos can also describe the condition of structures and/or equipment and vegetation of the target area. The inventory that may be taken can be set into such classifications as outdoor recreation (golf courses, marinas, yacht clubs, stadiums, parks, amusement parks, zoos, botanical gardens, museums, fairgrounds, swimming beaches or pools, etc.); vacant land (lots within neighborhoods, schoolgrounds, neutral grounds, etc.); wetlands (marshes, swamps, etc.); water resources (Mississippi River, Lake Pontchartrain, bayous in New Orleans East, etc.).

The advantages of using aerial photography in comprehensive recreation planning are particularly important in keeping up to date information on the expanding parts of the city, i.e., New Orleans East and Algiers. NORD would then be able to determine the need of retaining some land as open space for recreation. In this way, budget requirements could be set with supportive visual evidence. Open land could be identified and title search begun on the land to facilitate the acquisition process.

Recreation Site Planning

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The second potential primary use of aerial photography by NORD is recreation site planning. Aerial photography can show the topography of the site, the land use of surrounding areas and the accessibility of the space to the pedestrian or the auto. Also, it may help the decision maker in determining the use of the space in that color infrared can show the amount of air and/or water pollution. Surely, active sports should not be played in areas in which certain maximum levels of air pollution can be determined nor should swimming or related water sports be allowed in polluted waters such as Lake Pontchartrain. Another features which aerial photography may be used for is in recreation site planning safety measurement. If a site is located next to an open drainage canal, or a busy street, then necessary precautions are indicated, in order to protect the welfare of the user groups. This is an important consideration regarding potential litigation.

One important advantage of using aerial photographs in recreation site planning is that it can save time and money by limiting the need for on-sight visual inspections. Also, if the aerial photographs are triangulated (put to scale), location of specific recreation areas, facilities, trails, and roads can begin to be determined. In addition, aerial photographs can provide visual evidence for locating areas and facilities in need of maintenance, and for establishing repair schedules.

The aforementioned uses and advantages of aerial photography appear to be an important contribution in improving the process of urban open space and recreation planning.

Summary

Recreation planning is just now coming into its own as a discipline. As it does, and moves away from the unfair image of the well meaning but dull playground supervisor, the need for photos to survey recreation sites will be important. No other method gives the clues to recreational behavior as do photos. "Cluster analysis" of individuals at leisure gives us clues as to how and what will work in recreation. In addition, we can use the photos to be a publicity device and publicize events as desired.

POLICE AND FIRE DEPARTMENT USE OF AERIAL PHOTOS

Police

There are numerous uses the Police Department can make of aerial photos.

1. Training -- Both at the Police Academy and the Precinct, the officers have a real need for good photos of areas they will cover. The clustered nature of many of our older areas coupled with lush vegetation makes searching through many areas a real chore. Knowledge of certain patterns of land use and building configuration translates into better acquaintance with high crime areas. Patterns of various areas of the region can be emphasized to show, e.g., the best ways to cordon off an area or to seal off a particular type of building or facility. In particular, a basic familiarity with such facility types as wharves, dock holding areas, large industrial concerns with open lot storage and sprawling shopping centers can avoid a great many miscalculations. In that many facilities are not open for general inspection and on-site visits are time-consuming, this training can be a valuable substitute.

2. Crowd Control — An urban phenomenon engendering both excitement and fear is that of large crowds. Whether trouble is expected or not, crowds in and of themselves present problems. Aerial photos may be the only good method of analyzing crowd formation, movement, and dispersion. Comparative studies over time reveal changes in the process. Conditions that either deflect crowds into unwanted areas or bottle crowds up unwisely stand out in photo analysis. Yet, a ground observer may be resented if he takes crowd photos; even a vantage point is somewhat vulnerable.

3. Deployment of Personnel — a department cannot cover everything; increasing attention is being given to strategic deployment. Occurrence statistics are being "profiled" to predict the likelihood of crime occurrence by type. As these estimates become more sophisticated, they can be cross-analyzed with aerial photos of effected areas. Nature of crime and nature of area go hand-in-hand. Deployment can be estimated in various combinations or approaches to determine likely success in a critical situation. Beyond the training situation, if the Police had a coded grid map keyed to a central location where city aerial photos were available, queries could be answered as to nature of area, building lay-out, etc. Based on this information, officers could program their behavior with more detailed information on the physical characteristics of the area.

Fire

1. Fire Prevention — Aerial photos, as noted in the section on urban blight, can pinpoint accumulations of trash and debris which are fire hazards. On site

inspection of all sites continually would be not only impracticable but possibly dangerous. Aerial coverage, re flown periodically, can match inspection people with areas deemed probably hazardous. Enforcement is facilitated because a record, acceptable in court, will exist documenting the existence of the cited hazard and whether that hazard has been removed.

It is also possible to identify areas in which highly flammable substances are stored. Photos of the area can allow a fire department officer to monitor in general any changes in storage conditions or procedure. Coupled with periodic on-site visits, there is little doubt but that enforcement would be enhanced.

2. Fire Control -- Aerial photos of large areas, particularly if this information could be made quickly available on request could help fire commanders analyze the area in which they are fighting the fire. Given the possibility of going anywhere in a precinct on call as well as supporting other companies in unfamiliar areas, a general use of aerial photos could be a great aid. Certain types of photos could aid in actual fire fighting by serving to provide directions in areas that are blanketed by smoke.

3. Fire Analysis -- Photos taken after a fire - particularly one of some size - can help in the analysis stage. Coupled with reports on traffic and access or egress, they compile a portfolio on fires that is a valuable record.

AERIAL PHOTOGRAPHY APPLICATIONS FOR THE BOARD OF COMMISSIONERS (DOCK BOARD) OF NEW ORLEANS

An interview was held with Colonel Haar, Director of the Planning Department of the Board of Commissioners of New Orleans and his chief planner. Both men

were very enthusiastic about the applications they had already found for low altitude black and white aerial photographs.

The Dock Board uses a photo mosaic of the city for planning purposes which was taken in March 1972 at a cost of \$200.00. It is set at a scale of 1:100. According to the chief planner, the money has been well spent as aerial photographs provide them with ten times the information as an equivalent map. The following is a discussion of the uses of aerial photography for the Dock Board.

Topography Analysis

From aerial photographs, the planning staff can determine the amount of batture that currently exists along the Mississippi River. The interrelationships of road patterns, railroad tracks, and dock facilities can also be observed. With this information one can determine, monitor, and correct, where need be, accessibility problems to the docks.

Site Planning

An accurate triangulated aerial photograph can provide valuable information for site planning. One can determine the amount of space available for development and analyze the land use on and around the site. The following is an example of how the dock board planners recently used a triangulated aerial photograph.

The Dock Board acquired land along the Mississippi and an aerial survey was taken of the area. Photo interpretation revealed poor street conditions, congestion on the rear of the site and submerged pilings. None of these elements had shown up on existing maps of the area. Because the aerial photographs had been

triangulated, an expensive ground survey was avoided. To develop the plan to the correct dimensions, the planner merely had to take measurements off the print and keep in mind the visible relevant factors.

Another example of the use of aerial photographs was in Eastern New Orleans, along the Intracoastal Waterway. The Dock Board wanted to construct a road from its property to an access road. Triangulated aerial photographs enabled planners to calibrate the distances involved and to observe a pipeline not shown on the Dock Board map, that crossed the proposed roadway. Shacks illegally constructed by squatters living on land which was intended for the roadway were easily seen. Here again an expensive site visit was avoided.

Policy Actions

The heavy volume of traffic on the Mississippi River and Industrial Canal is often dangerously congested with improperly moored ships and barges. To insure the continued safe passage of ships and barges, the Dock Board must control the proper placement of water crafts along its wharfs. Aerial photographs can show where violations occur and which company is responsible, so that illegal moorings can be recorded and corrected through the legal process if need be.

Educational Tool

The photographs that the Dock Board have are used extensively for intra-agency communication. The planners find that administrators are more easily oriented when discussing specific conditions or changes using an aerial photograph. Moreover, the port facility is visited by many businessmen from across the United States and the world and aerial photographs are used for orientation purposes before the dock facilities are toured.

Summary and Conclusion

Personnel at the Dock Board presently rely on low altitude aerial photographs (black and white) for planning purposes. No use is made of color/black and white high altitude or satellite photographs, because of their high cost. However, if the cost could be reduced or shared among other users, the Dock Board may be willing to make use of these photographs.

APPLICATION OF AERIAL PHOTOGRAPHS TO TRACE GROUNDWATER

The continued supply of water to expanding cities is essential for industries and people to survive.

The S.M.S.A. of New Orleans is not unique in its demand for water; this demand has increased as the area has grown. Recent reports by the Environmental Protection Agency have indicated that the main source of water for the New Orleans S.M.S.A., the Mississippi River, has numerous trace chemicals and elements that may be harmful to human health if ingested in large enough concentrations. Further research is now being conducted to determine what is creating the problem and the maximum levels of known trace chemicals/elements that humans can safely consume. Although it is not believed, at this time, that a new source of water will be needed, it is important to consider other potential water sources if an emergency situation arises in the future.

Aerial photography has been successfully used to locate groundwater through the fracture trace method. Basically, aerial photographs are taken of land areas before urbanization takes place in order to locate the natural fractures in the earth's surface. It is imperative that aerial photo water prospecting be conducted before man

has disturbed the soil. Through detailed examination, a trained person can locate fracture sites which indicate potential sub-surface water deposits. Drilling on these sites is the only true means to determine if water is available. By using the aerial photo fracture trace method, the hit and miss of traditional water prospecting is avoided, which translates into dollar and time savings. Furthermore, potential water supply sources are identified for future use by expanding urban areas.

THE USE OF AERIAL PHOTOGRAPHS BY THE ORLEANS LEVEE BOARD

According to Mr. L. G. Bolet, Assistant Chief Engineer of the Orleans Levee Board, aerial photography on a regular basis is not presently needed because daily inspections are conducted by maintenance crews along the Orleans Parish lakefront levees. However, black and white aerial photographs at a scale of 1:100 have been used in the past to survey damage to the levees and adjoining property after extreme high winds and hurricanes. Specifically, these photographs are used to document the condition of the levee system, the extent of flooding and damage to trees and other types of vegetation for purposes of planning needed repairs.

Although the aforementioned represents the extent of the use of aerial photographs (black and white) by the Orleans Levee Board, it would appear that the cost of color infrared aerial photographs could be shared with other public agencies and governmental bodies, providing a valuable monitoring service for the Orleans Parish levee system. With the technology of aerial photography advancing, periodic detailed analysis of the structural soundness of the levee system should be possible so detection and repairs can be made in advance of storms and hurricanes without

daily site visitations. The use of aerial photographs (color infrared, etc.) as an early warning system should therefore, be considered by the Orleans Parish Levee Board, if potential catastrophic events are to be minimized.

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APPENDIX C

TRAFFIC STUDY BY REMOTE SENSING

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TRAFFIC STUDY BY REMOTE SENSING

The application of time-lapse photography as an analysis tool for kinetic systems is well known and the application to traffic analysis seems obvious. Since traffic systems are large in size and data content, there are some questions with regard to this application, such as platform, data acquisition, data handling and output requirements. To answer some of these questions a number of experiments were performed.

First a visual study was done on existing NASA photography in the area. Existing satellite imagery did not have sufficient resolution and suffered from a lack of sufficient overlap of images. Photography from RB-57 and U-2 at 65,000 feet also lacked resolution and the frame repetition rate gave only 50% useable overlap. Longer focal length lenses and a higher repetition rate might make this system effective. Other photography, taken at about 30,000 feet with equivalent cameras provide useful results. Basic traffic parameters such as speed, volume and density were measurable.

In an interview with John Exnicious, he indicated that for his needs he would like to have certain parameters.

VOLUME - an expression of the number of vehicles passing a specific point per unit time.

DENSITY - an expression of the number of vehicles per unit length of roadway.

SPEED - maximum, minimum and mean speeds per street, block and lane.

Several experiments were then performed to determine the ease or difficulty with which these data could be derived. On the occasion of a visit to New Orleans of the Goodyear Blimp for a Superbowl Game, a camera and cameraman were placed on board and a series of pictures were made in the area. Similar experiments were performed with a Marine Corps helicopter and with a NASA contract airplane.

With regard to the platform, the Blimp was superior in respect to being able to maintain position accurately for extended periods of time. The area covered was limited by the service ceiling of about 6,000 feet. This area could be improved by use of wider angle lenses but this would introduce relative distortion.

The helicopter proved to be a useful platform with similar altitude limitations. It has the capability of staying on station with reasonable accuracy. This accuracy could be improved somewhat by some sort of compensating mount for the camera. The experiments were performed at 1500, 3000 and 6000 feet. It was shown that the 6,000 foot photography was effective, but for examination of data acquisition problems, a set of photographs taken at 3,000 feet over the interchange crossing of Pontchartrain Expressway and South Claiborne Avenue.

This was a limited experiment in that the area covered was about one square mile and only some fifty vehicles were studied. Even so, the manual extraction of data was most tedious. To reduce this tedium and improve efficiency an "R - O" machine was used. This is a potentiometer controlled pointer-arm, wherein the voltage on two potentiometers will define the position of the end of the pointer in polar coordinates. These voltages are read by a digital voltmeter and converted to punched card

format. With this system, equivalent, fixed control points in paired photos are entered and all subsequent measurements are related to these control points. Making these measurements on all targets of interest, we establish the spatial coordinates of each in both photos. The differences yields the displacements which, divided by the elapsed time between photos, yields the velocities. The cards were used as input to a small computer program to calculate results.

For basic control of such an experiment, it is necessary to have ground truth for distances. This can be accomplished by setting out recognizable markers at a known separation distance at the time of the experiment or by acquisition of an adequate base control map. The map must have photo recognizable features where separatory distances can be scaled accurately on the map and relatively on the aerial photographs. After some search, we found that the local utility companies have and maintain such maps.

Some of the results of this experiment are shown in Table A-1. This experiment showed that conditions could be evaluated for one instant at a traffic node.

Subsequent discussion with the Traffic Engineers confirmed the effectiveness of the above experiment and revealed a broader need. For nodal (intersectional) analysis, sample data was required at various times in the day and week and under various load conditions. This low altitude method will certainly work better than the existing methods using pneumatic vehicular sensors or observers. This method has the additional advantage of separating vehicles by type.

Another experiment performed on this data set was an attempt at photographic subtraction of the background. A positive transparency of

3000 FEET

	SPEED (mph)			TOTAL CARS	DISTANCE (feet)	DENSITY CARS/300'	LANES
	MAX	MIN	MEAN				
PONTCH. EXPWY							
Lake Bound	51	33	44	14	1282.5	3.27	3
River Bound	43	16.3	26	16	1350.7	3.55	3
SO. CLAIBORNE AVE.							
North	35.5	11	18	12	1594.7	2.3	3
South	36	29	32	3	953.89	1.26	3

TABLE A-1

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one photo was overlaid on the negative transparency of its companion. With proper registration everything disappears except those objects in motion between exposures. The objects in motion resemble a television image with ghost. This technique suggests a photosubtractive technique for automation of data extraction. While this is a most desirable objective, its attainment is difficult and certainly expensive. If one uses a subtractive mask and overlaps a series of data photos, registration will be critical and some electro-optical sensor will be needed to extract data for subsequent processing.

These difficulties suggest reducing at least one link in the system by using an electro-optical sensor as the prime data acquisition sensor. The use of a TV camera on the remote platform and the temporary storage of the acquired data on video tape would provide a computer compatible format for data processing.

It may be that the ordinary television camera may lack sufficient resolution for broad application in this area, but television systems of higher resolution are known and available.

Using the video tape format for computer input, the subtraction technique for adjacent frames would reduce data handling requirements enormously or enhance the signal-to-noise ratio by largely eliminating the "noise".

The practical implementation of this new system for traffic analysis will require the use of data extraction mechanisms which will support the prompt delivery of information to the user.

The present methods involve the study of a node, corridor or area. With remote sensing, the node study and area study could be

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accomplished by low and high altitude stationary platforms while the corridor analysis would adapt to low altitude aircraft flights along the corridor. The present methods are very expensive. The data is gathered from pneumatic counters and observers and is averaged over a period of time, usually weeks. It will often take 12 to 30 weeks to prepare a detailed report for the user. At this point, the user must make future decisions on an "average" body of data that may be three years old.

In addition to being timely and condition responsive, this new system makes possible the use of other combined variables which would be useful to any attempt at modelling or traffic simulation. That is, this method would allow for the extraction of speed distribution data, spacing between vehicles and statistical distribution of spacings as a function of speed.

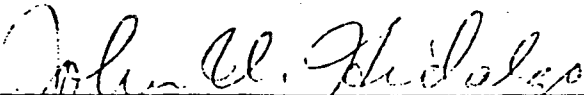
Nothing in this new system would require new inventions but it will require adaptation of existing technology to these important problems.

APPENDIX D

Preliminary Notes
on
Analysis of Urban Conditions
With Data From ERTS-1

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A very early but encouraging step has been taken in the recognition of various urban conditions from digital satellite tapes.

The starting point was a color-composite photograph, in which each point in the satellite view of New Orleans was represented by a combination of three colors. The depth of each color stood for the intensity of the point in one of three spectral bands. (The satellite actually made four photographs at a time, using four different filters, one green, one red, and two at different wavelengths in the infra-red.) The result was a melange of reds and blues, as one of the infra-red photographs was imaged in red, the visible red in yellow (which we see practically none of), and the green in blue.

Where this picture was scaled to a map of the city, unmistakable associations could be seen between tints of the picture and conditions around town. For example, one could trace the course of St. Charles Avenue from clear red uptown (characteristic of plentiful tree growth) to solid blue downtown (characteristic of certain pavements). Parks and cemeteries were discernible, as were shopping centers and major highway interchanges.

But all this was subjective on two counts: the estimation of the color mix and the condition of the neighborhood. We have since been able to make both these factors more nearly rigorous.

At first we retained the visual estimate of color but defined neighborhoods and neighborhood conditions in accordance with a report

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by the New Orleans City Planning Commission based on the 1960 census and later updating surveys.¹ For purposes of this study, the city was divided into 18 Planning Sections, each of which was subdivided into Planning Units. These latter correspond roughly to what might be called neighborhoods and were chosen with an eye to homogeneity. Then each Planning Unit was assigned to a quartile indicating its relative degree of physical blight, as well as to a quartile of social blight and a quartile of economic blight.

We used in one experiment four, and in another ten, subjectively determined color mixes (associated, be it remembered, with satellite photography through various filters). To this data we appended information about three² of the four quartiles described above. Some 60 neighborhoods were so characterized and then subjected to a statistical procedure known as Bayesian analysis. The computer uses the given colors, areas and blight quartiles of each neighborhood to construct a discrimination function. The object is to be able to distinguish blight quartiles from the composite color photograph.

Crude as the color input data were, the results were nonetheless sixty percent correct, which -- considering that a random choice would select each of the three quartiles one-third of the time -- is about twice as good as chance.

¹Community Renewal Program: City of New Orleans

²There were effectively no Quartile 1 units at all.

Next we seized the opportunity to improve our color input data and with it, hopefully, our discrimination function. The ERTS photographic information is also available in a form suited to a digital computer. On these magnetic tapes, each "resolution element" (the smallest area the camera can distinguish from 500 miles³) is represented by four numbers -- one for each of the four spectral bands, or filters through which the photographs were taken. (Note that the color-composite picture from which subjective estimates of color mix were made contained only three of these bands). Within each band the numbers range from 0 to 63, giving 64 possible different intensities through each filter.

Computer programs have been written to extract from the original NASA tapes the portions pertaining to New Orleans and its environs, and to put them in a form more convenient for our purposes. (For one thing, in accordance with the law on the natural perversity of inanimate objects, the region we sought was originally at the very end of a 2400 foot tape!) A first concern was to orient ourselves relative to the vast array of numbers available. From the published relationship between the photographic and digital presentations, we had, of course, a general idea. But in order to extract all the region we wanted with no excess, we first created a "density plot."

By this we mean a printed display of some portion of the tape (one spectral band only, or at least only one at a time), in which

³A rectangle of about 188 feet roughly east to west and 260 feet north to south.

various values from the 0-63 range are replaced by selected characters.

These can be chosen in such a way that "light" characters (a blank, for example, or a comma) stand for low numbers, while "heavy" characters (an asterisk or a dollar sign) stand for high numbers. We were delighted to find our first two such explorations revealed one the intersection of the Mississippi River Gulf Outlet with the Inner Harbor Navigation Canal, the other a portion of the lakefront and the Causeway.

From such plots, notable features of the city could be identified: the river and lake, of course, and many other waterways; Lakefront Airport; parks, highway interchanges, etc. Hence a grid could be constructed, superimposing on a city map the row and column coordinates within the taped array of densities.

This in turn made it possible to write a computer program which accepts a definition of a region, such as a neighborhood or a Planning Unit, in terms of these rows and columns. The program then consults the tape and prints out a crude picture of the region, each resolution element being shown by a cluster of the four spectral densities at that point. The program also counts the points and computes their average and standard deviation within each band, to give a compact glimpse of each band's central tendency and spread. A fuller view is given by a table of frequencies -- the number of occurrences of a given value in a given band. (This table is also printed in percentages, for inter-unit comparison.)

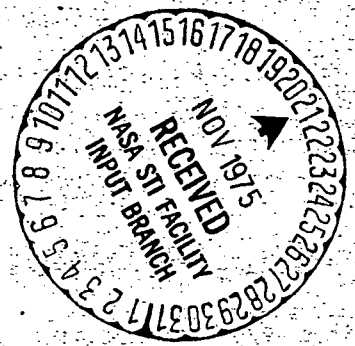
What can we learn by means of all these techniques? We are about

5.
to repeat the Bayesian analysis of color vs. blight quartiles, but using numerical "signatures" instead of subjectively described colors.

"Signature" here means a characteristic pattern of values over the four bands which can be associated with a particular ground truth.

By the merest inspection, we observe among the ten Planning Units so far analyzed in this fashion the following patterns:

Physical Blight Quartile	Averages over all Planning Units			
	Band 1	Band 2	Band 3	Band 4
2	34.4	28.8	39.8	19.4
3	37.1	32.5	40.2	18.8
4	37.1	32.7	35.6	15.5
C.B.D. ⁴	41.2	39.7	36.1	14.2



Scant as our sample is at this moment, it already appears that Bands 1 and 2 serve to distinguish Quartile 2 from Quartiles 3 and 4, and then in turn from the C.B.D. Bands 3 and 4 suffice to separate Quartiles 3 and 4. Hence the four kinds of neighborhood appear to have each a unique signature.

Our next step must be to expand our data set, to confirm (it is hoped) the early impression that useful signatures can be found. Only then will we be able to pursue their application.

⁴All Central Business District units are grouped together regardless of physical blight; their likenesses are greater than their differences.